Convergence Test of Qual Computational Scheme in DSM2

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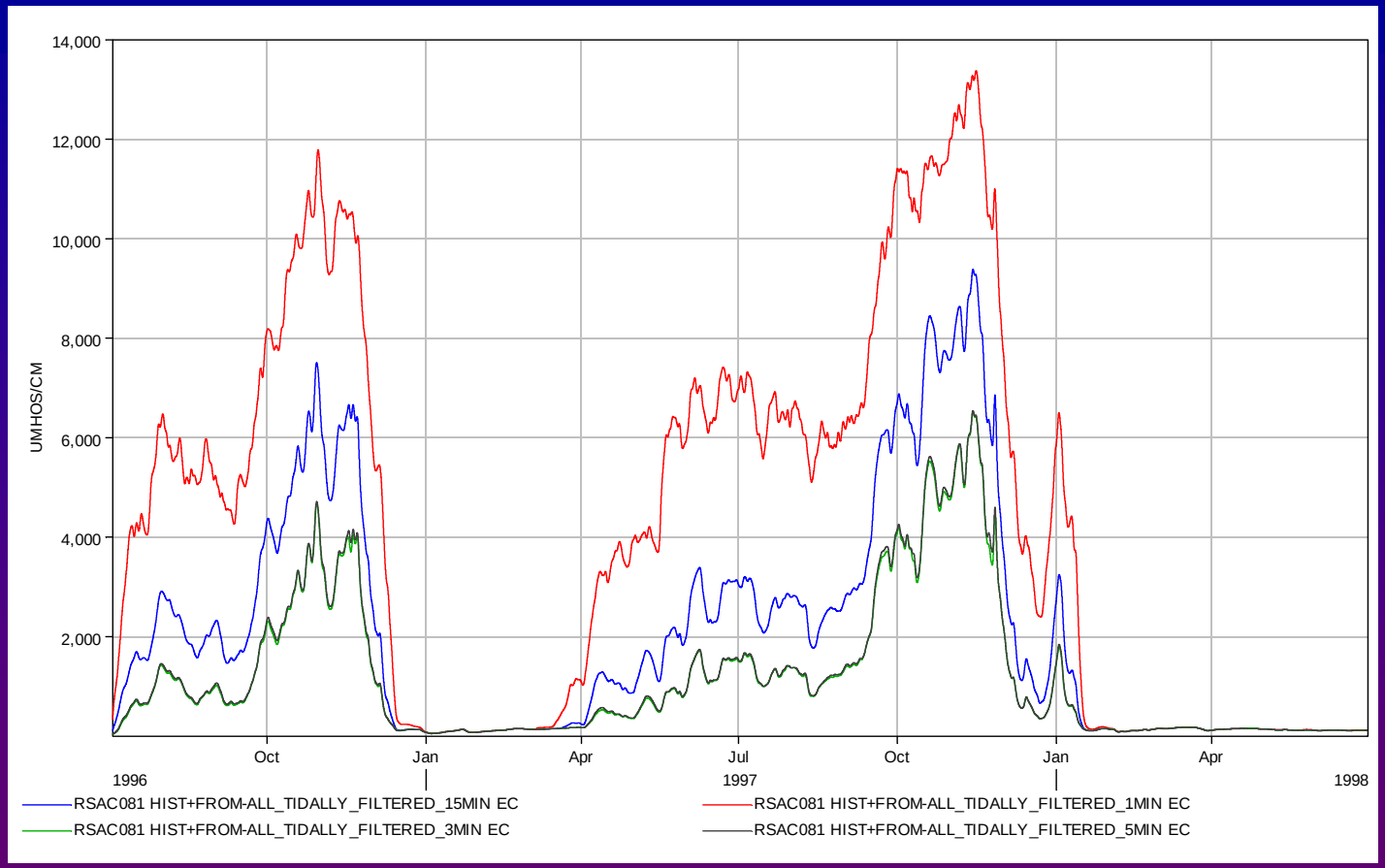
Background and Objectives

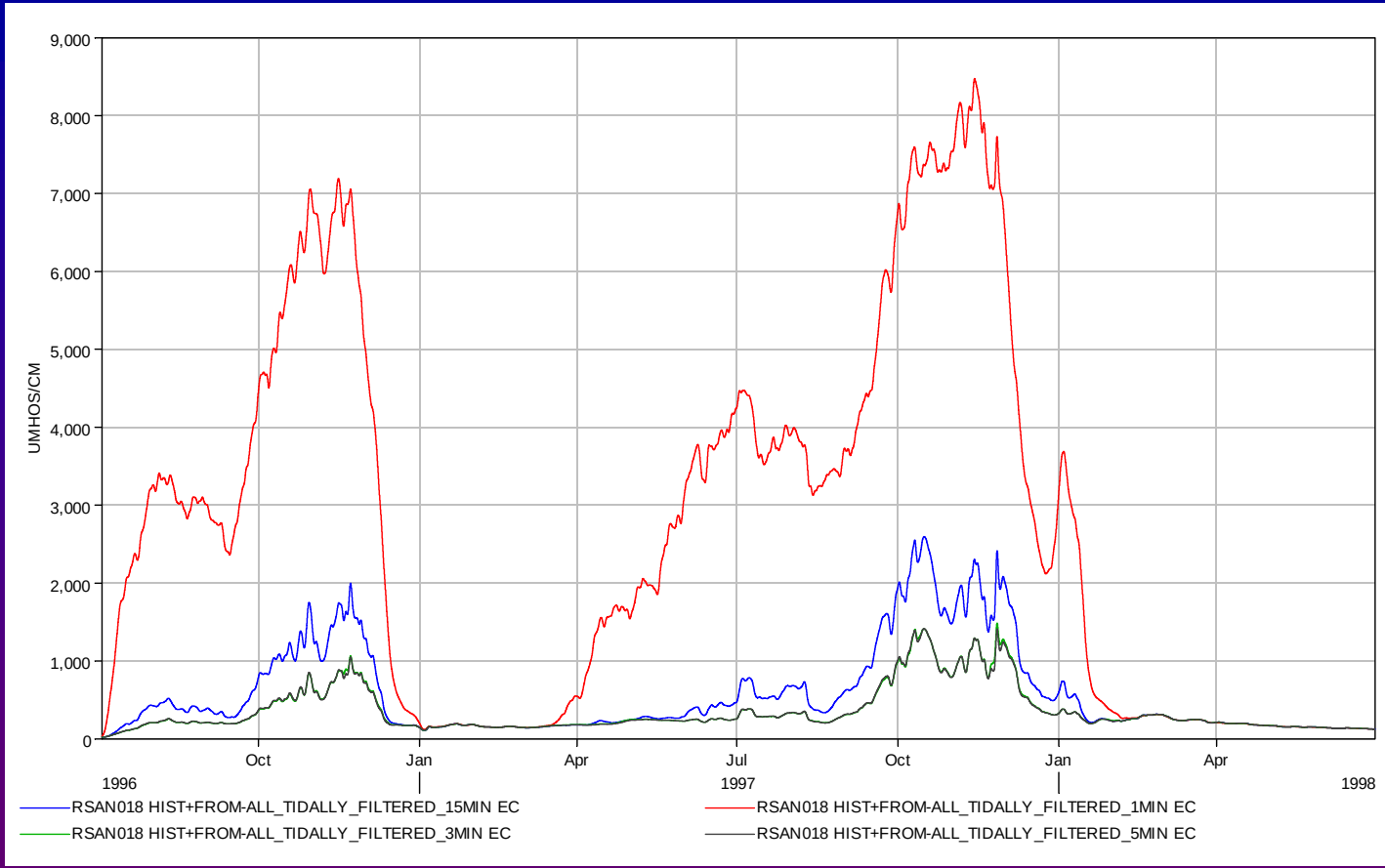
- **Convergence** test of the DSM2 Version 8 revealed some problems of the Qual model.
- A numerical model is **convergent**
  - only if a sequence of model solutions with increasingly refined grids/time steps approaches an identical solution.

Historical Run Test Results at Collinsville



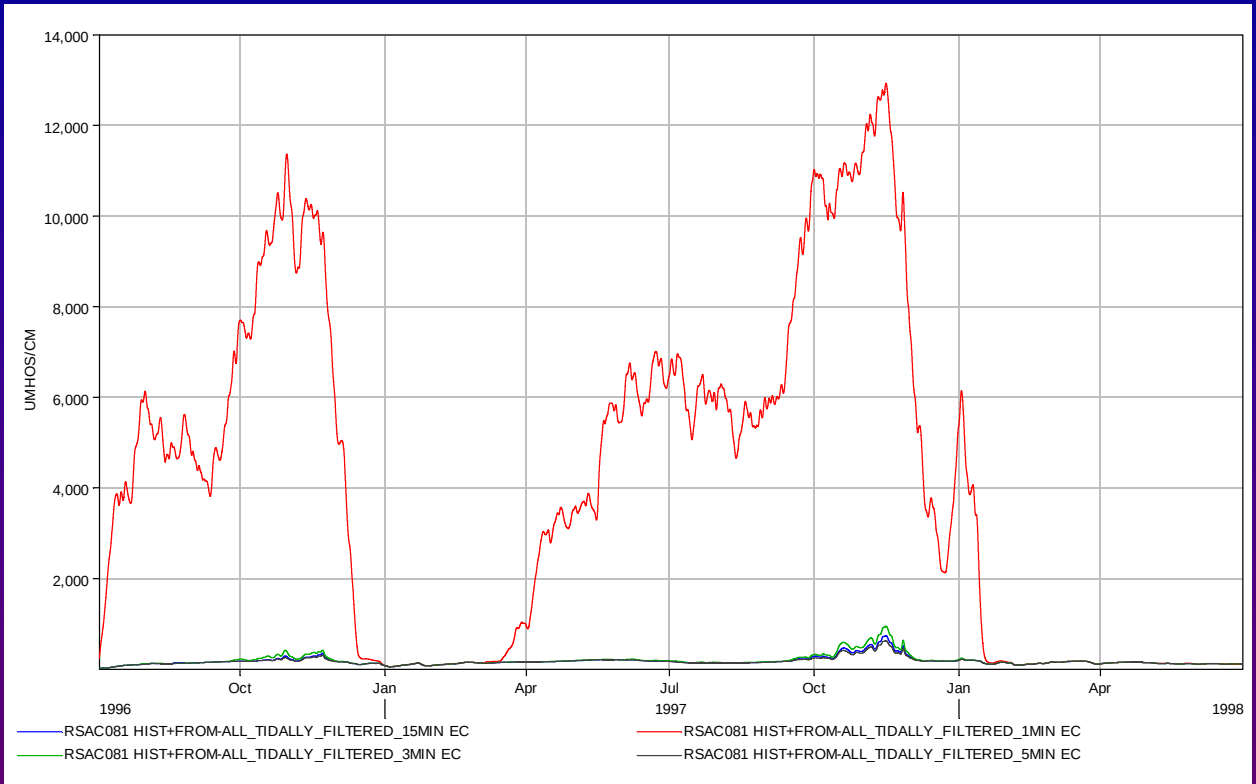
EC at Collinsville with time steps 15, 5, 3, 1 minutes

Test Results at Jersey Point (Version 8.0.4)

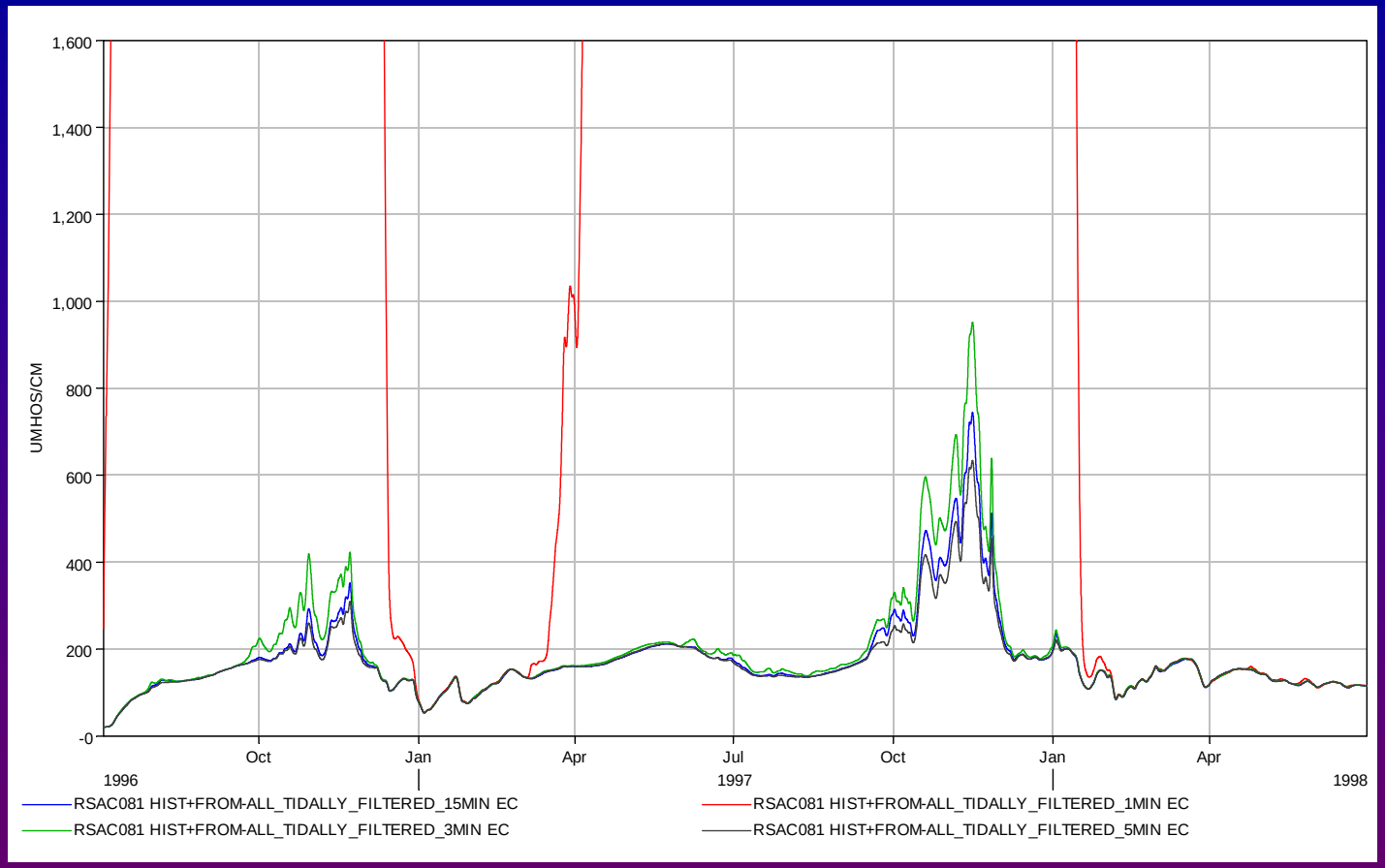


EC at Jersey Point with time steps 15, 5, 3, 1 minutes

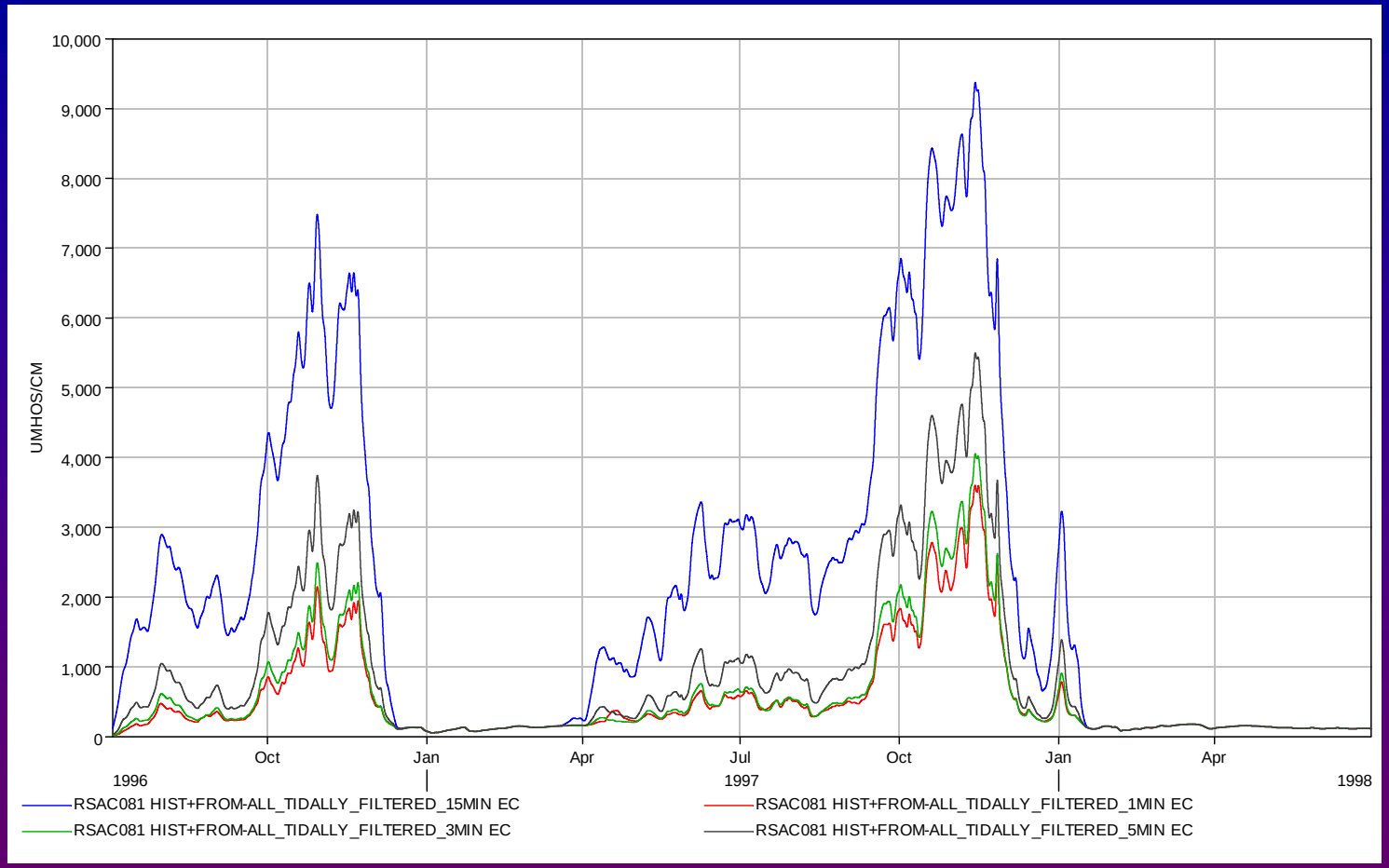
Advection Only
(By turning off dispersion, version 8.0.4)



Zoom in (Advection Only)

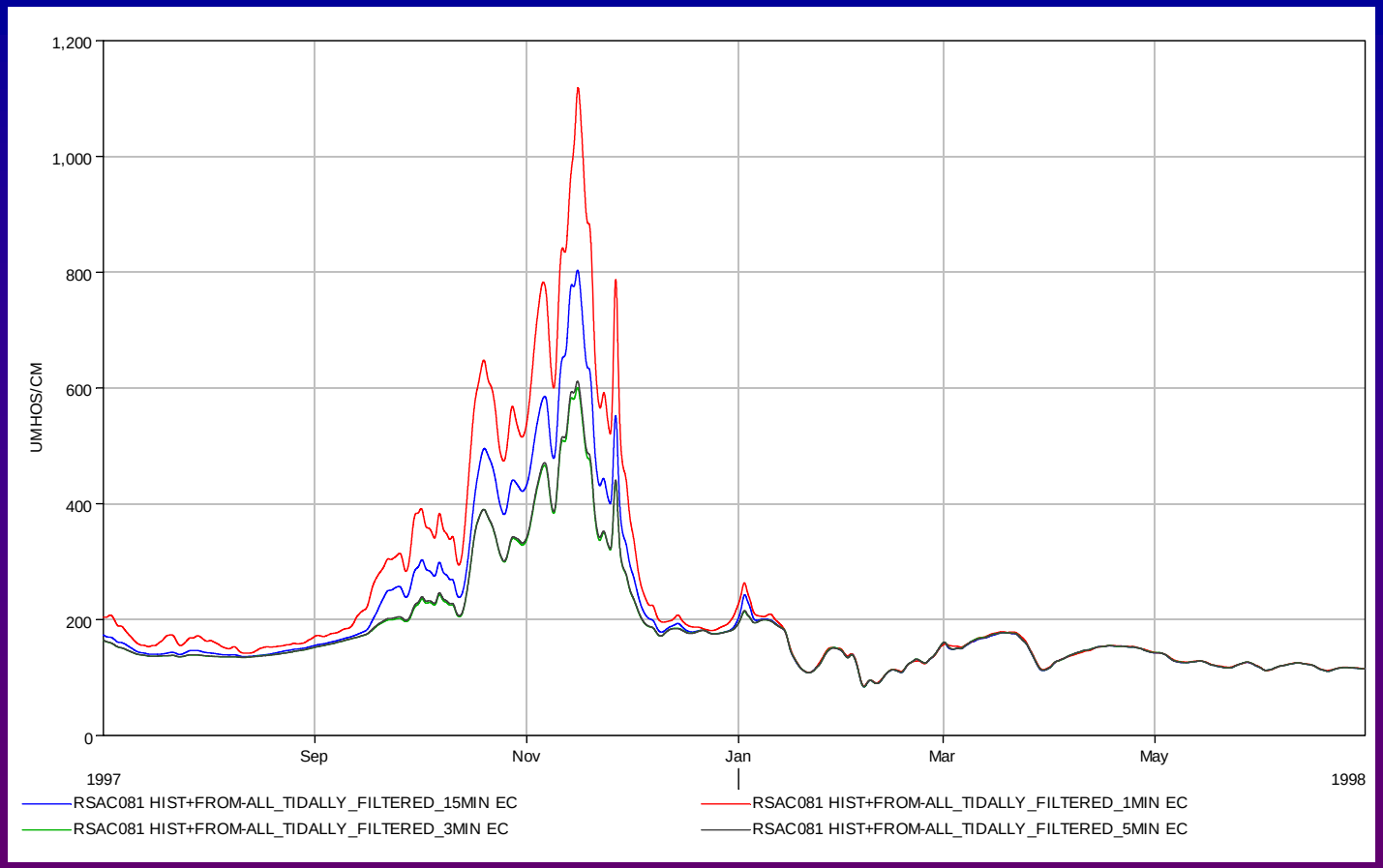


Old Model Results (Maximum parcel number = 72)



EC at Collinsville with time steps 15, 5, 3, 1 minutes

Old Model Results (Maximum parcel number = 72) Advection Only



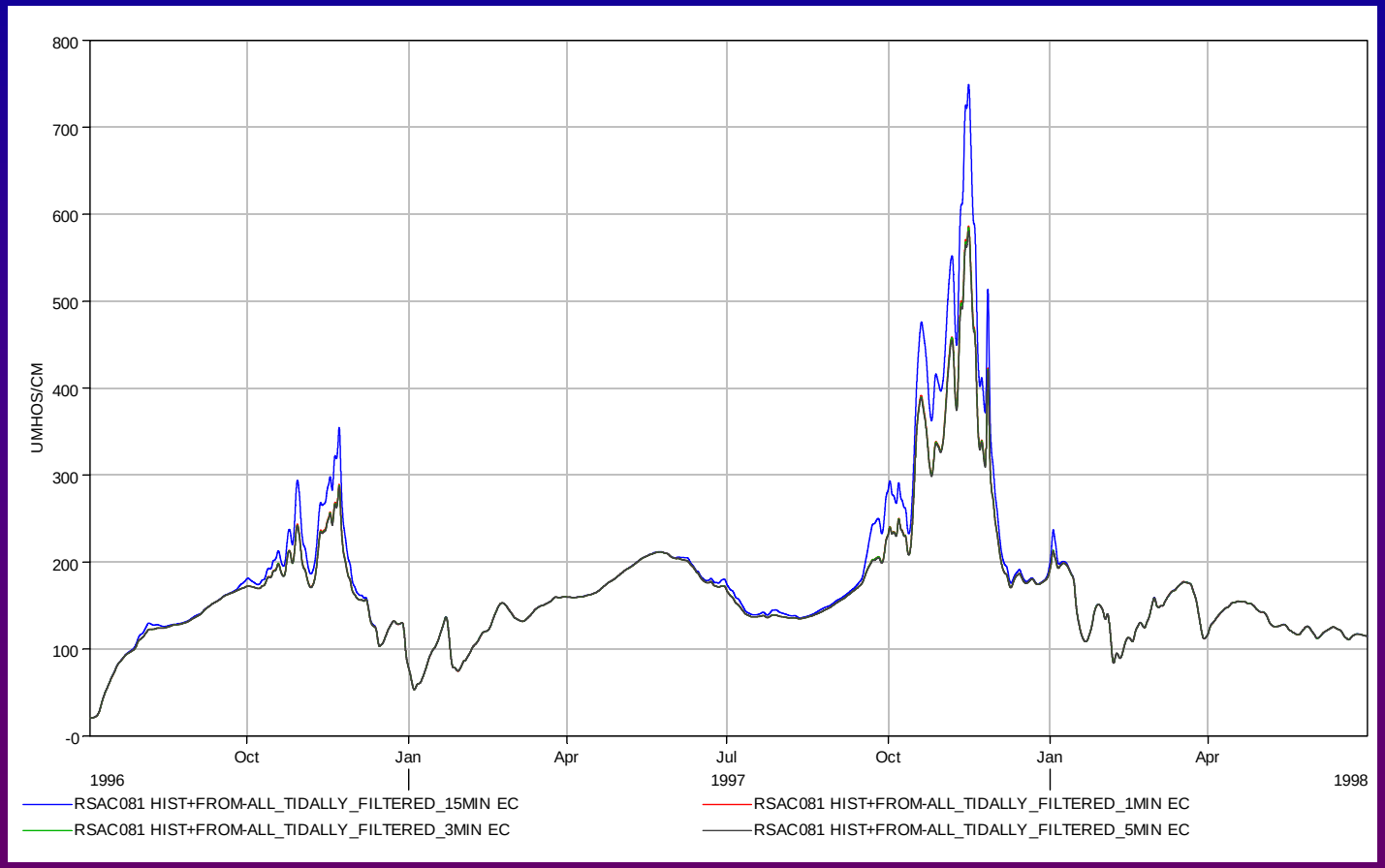
EC at Collinsville with time steps 15, 5, 3, 1 minutes

Advection fix

- The original model used a maximum parcel number (22) to control the parcel combination.
- A new user input variable of parcel size is introduced.
  - If a new parcel is smaller than the user defined size and the parcel next to it is also smaller than the defined size, they will be combined.
  - The goal is to keep parcels close to the defined size.

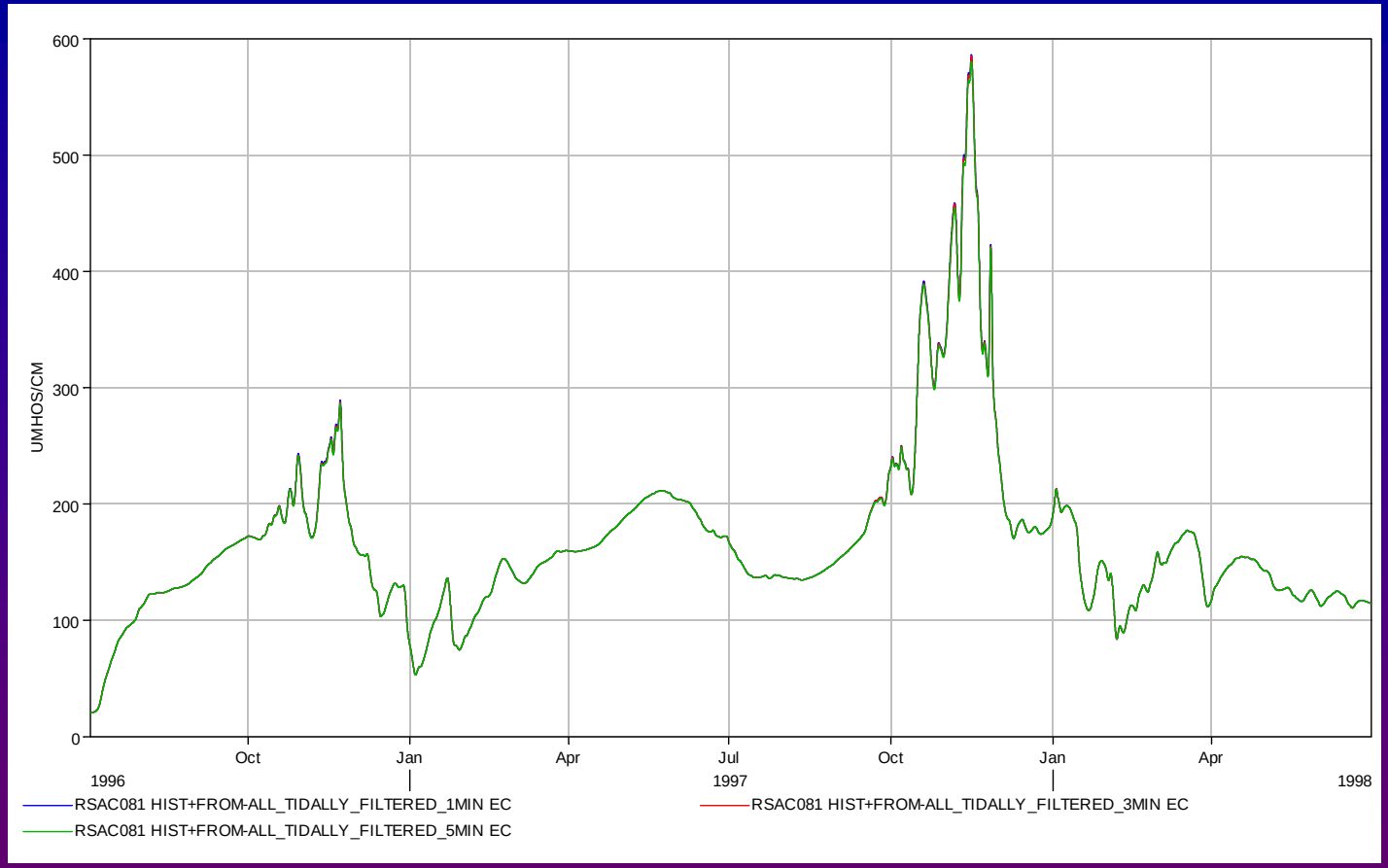
New Advection-Only Results

Parcel combination is refined. Parcel size is a input variable (500 ft in this test run).



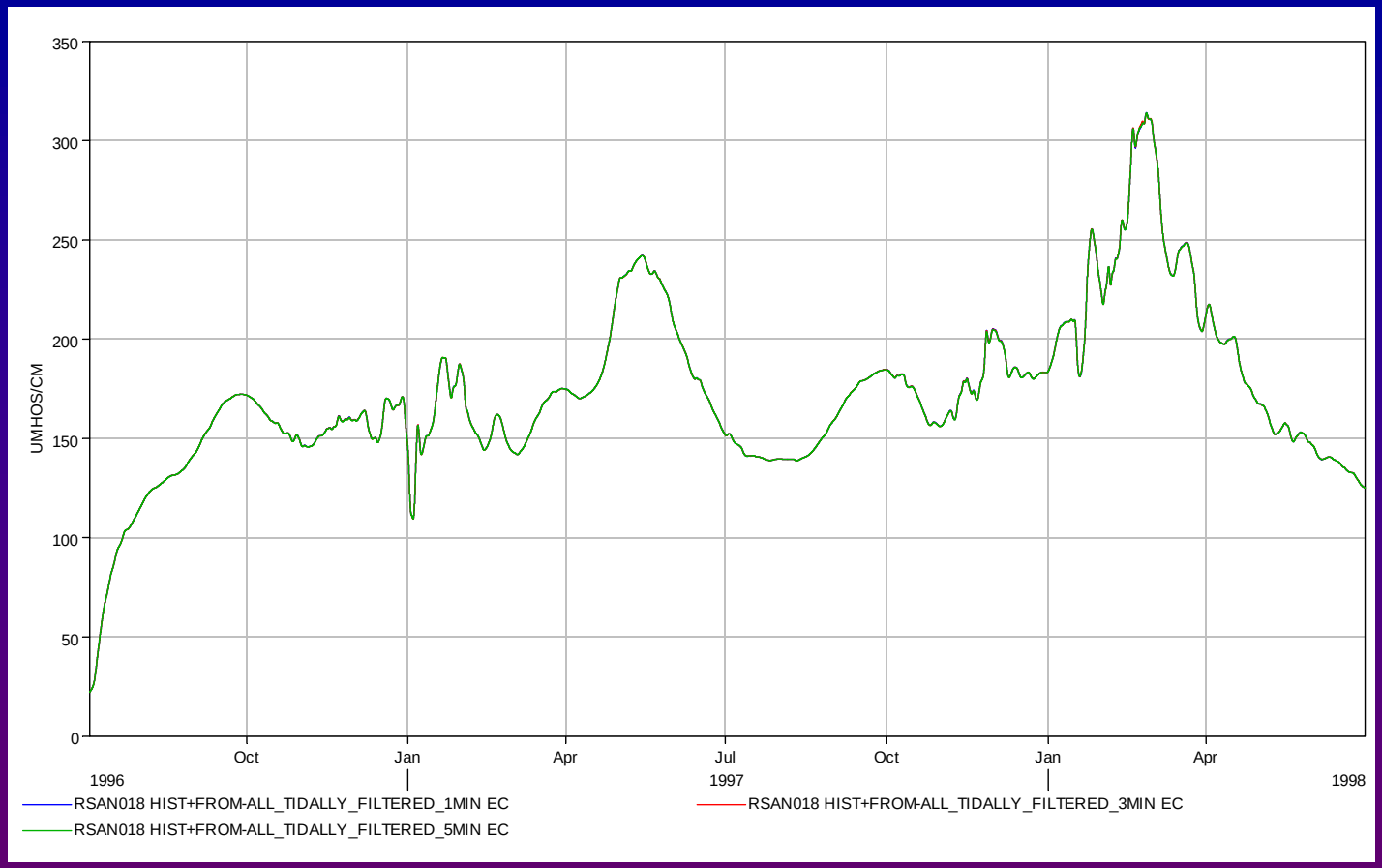
EC at Collinsville with time steps 15, 5, 3, 1 minutes

New Advection-Only Results



EC at Collinsville with time steps 5, 3, 1 minutes

New Advection-Only Results

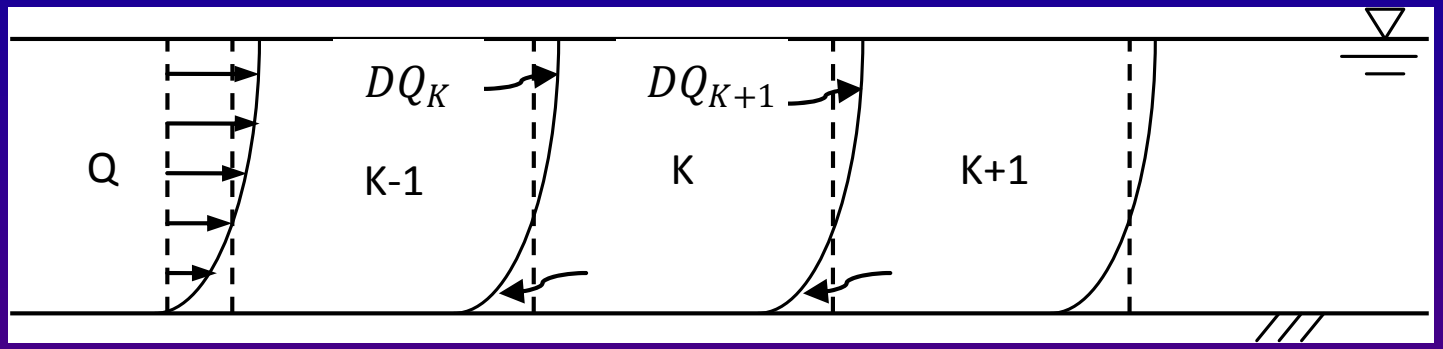


EC at Jersey Point with time steps 5, 3, 1 minutes

New Dispersion Formulation

The dispersion flux (rate of mass exchange) in the original scheme:

$$F = DQ_K(PT_{K-1} - PT_K)$$



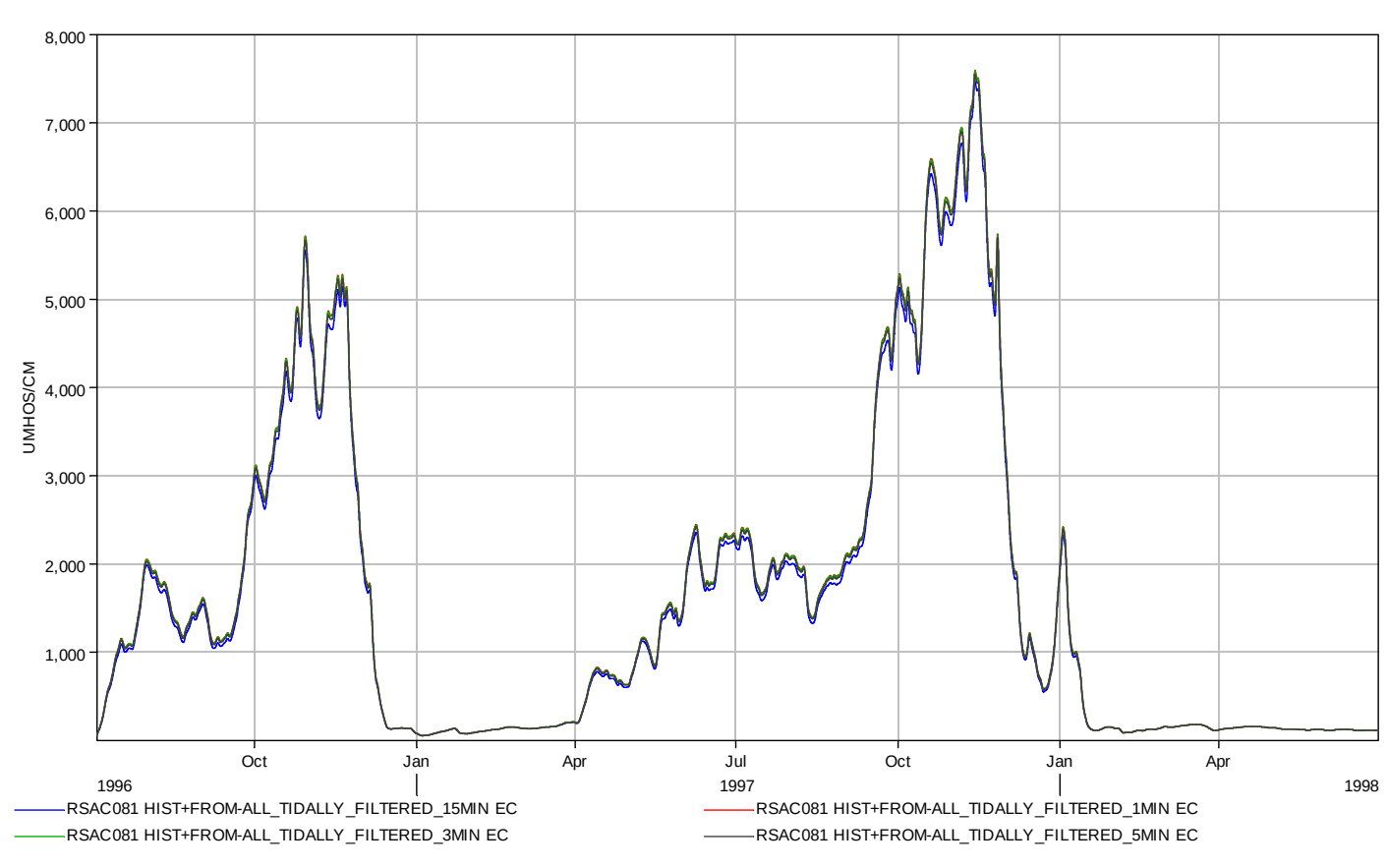
The mass exchange rate should be a function of concentration gradient:

$$F = f\left(Q, \frac{\partial C}{\partial x}\right) = -DC \cdot Q \cdot \frac{\partial C}{\partial x}$$

The mixing equation:

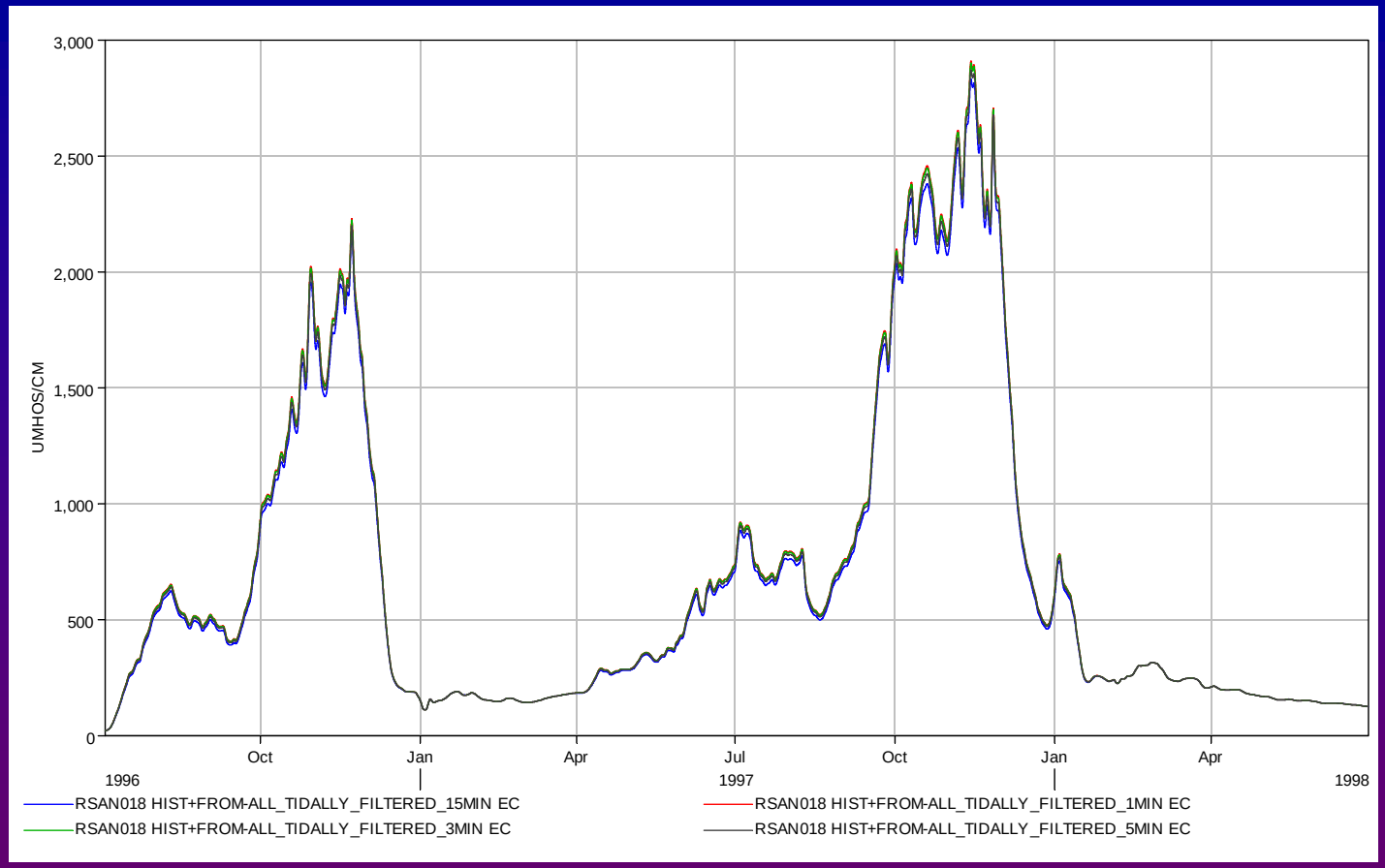
$$\Delta PT = DT * \left(DC_K Q_K \frac{PT_{K-1} - PT_K}{(\Delta x_K + \Delta x_{K-1})/2} + DC_{K+1} Q_{K+1} \frac{PT_{K+1} - PT_K}{(\Delta x_K + \Delta x_{K+1})/2}\right) / PV_K$$

New Model Results



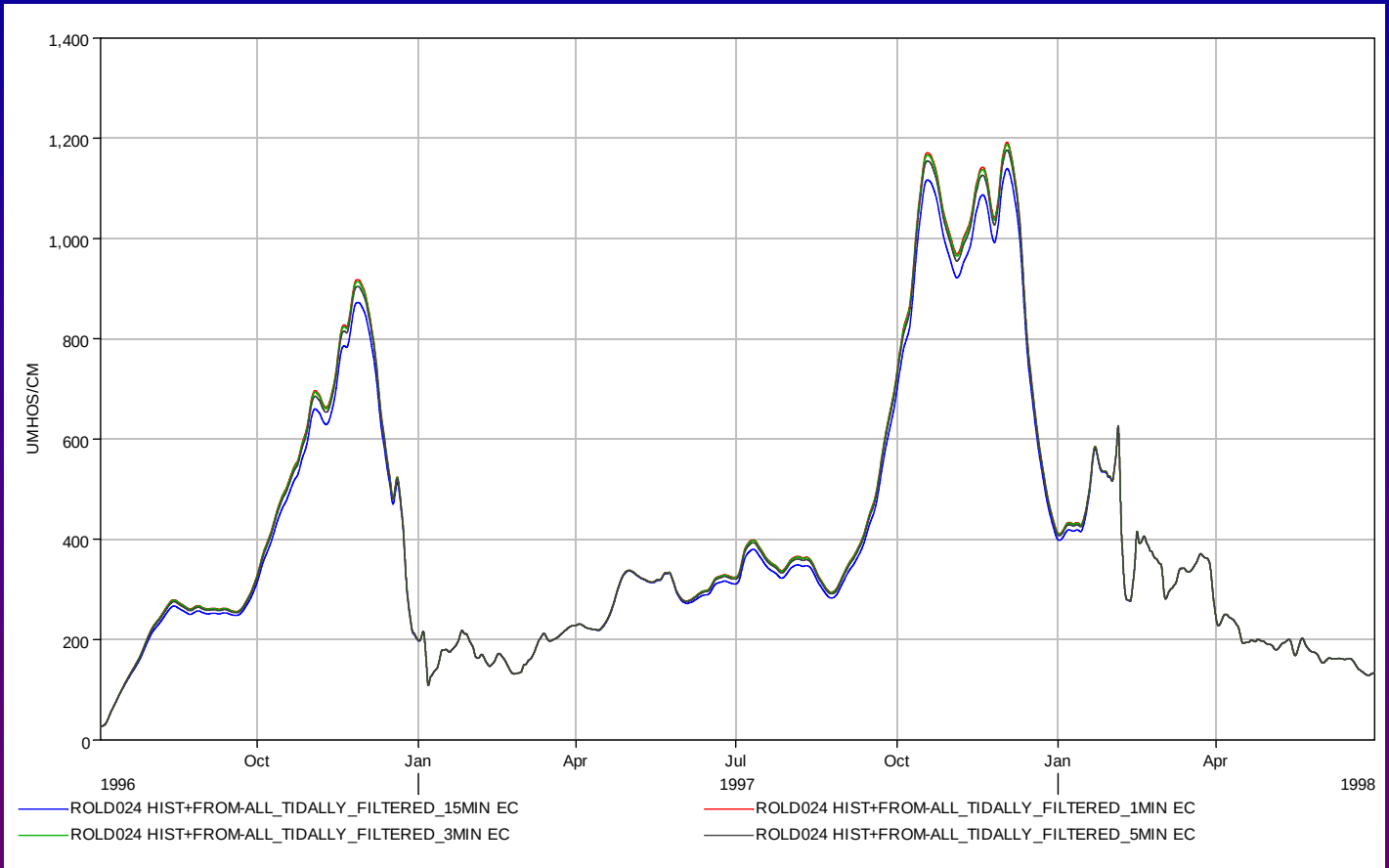
EC at Collinsville with time steps 15, 5, 3, 1 minutes

New Model Results



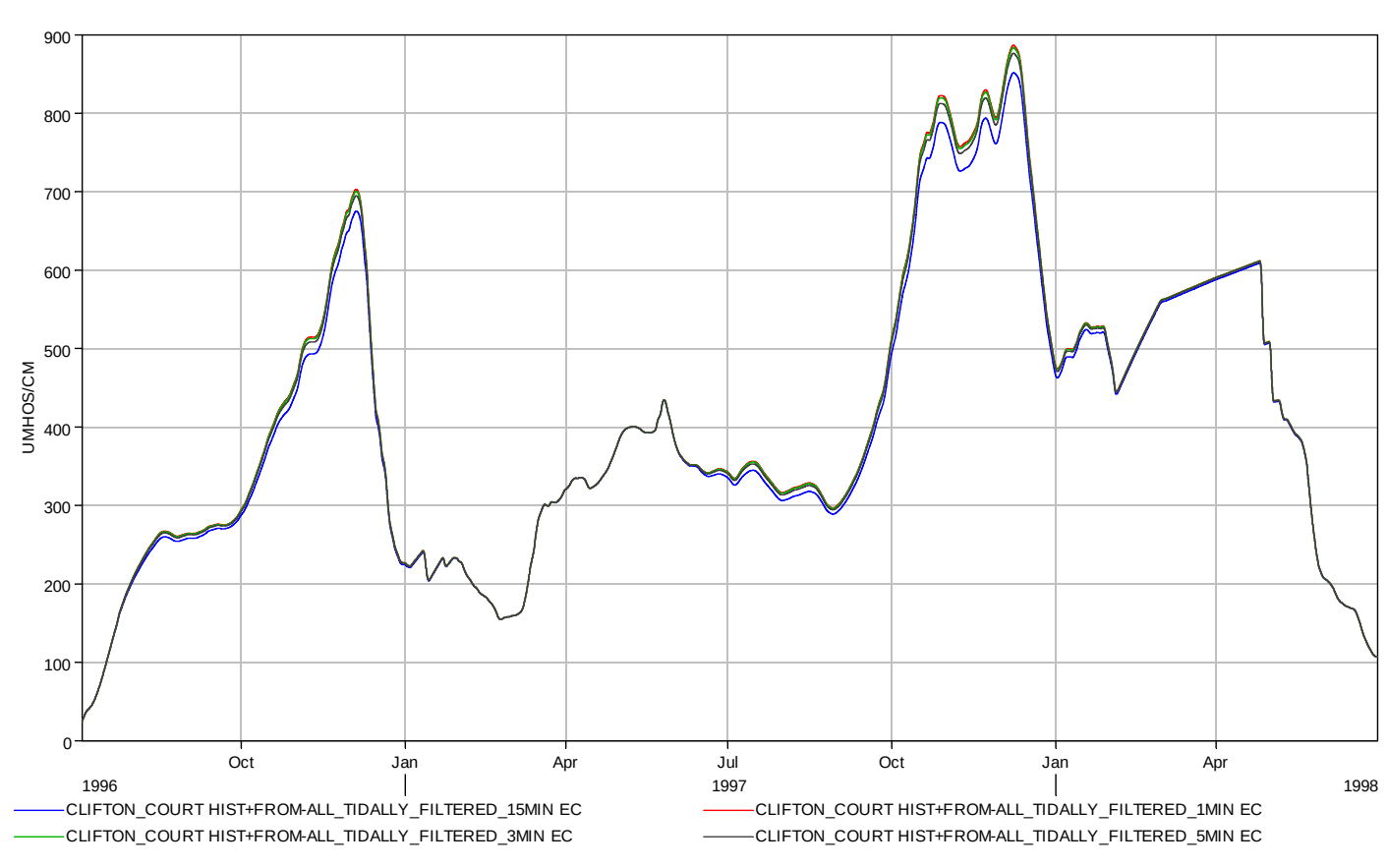
EC at Jersey Point with time steps 15, 5, 3, 1 minutes

New Model Results



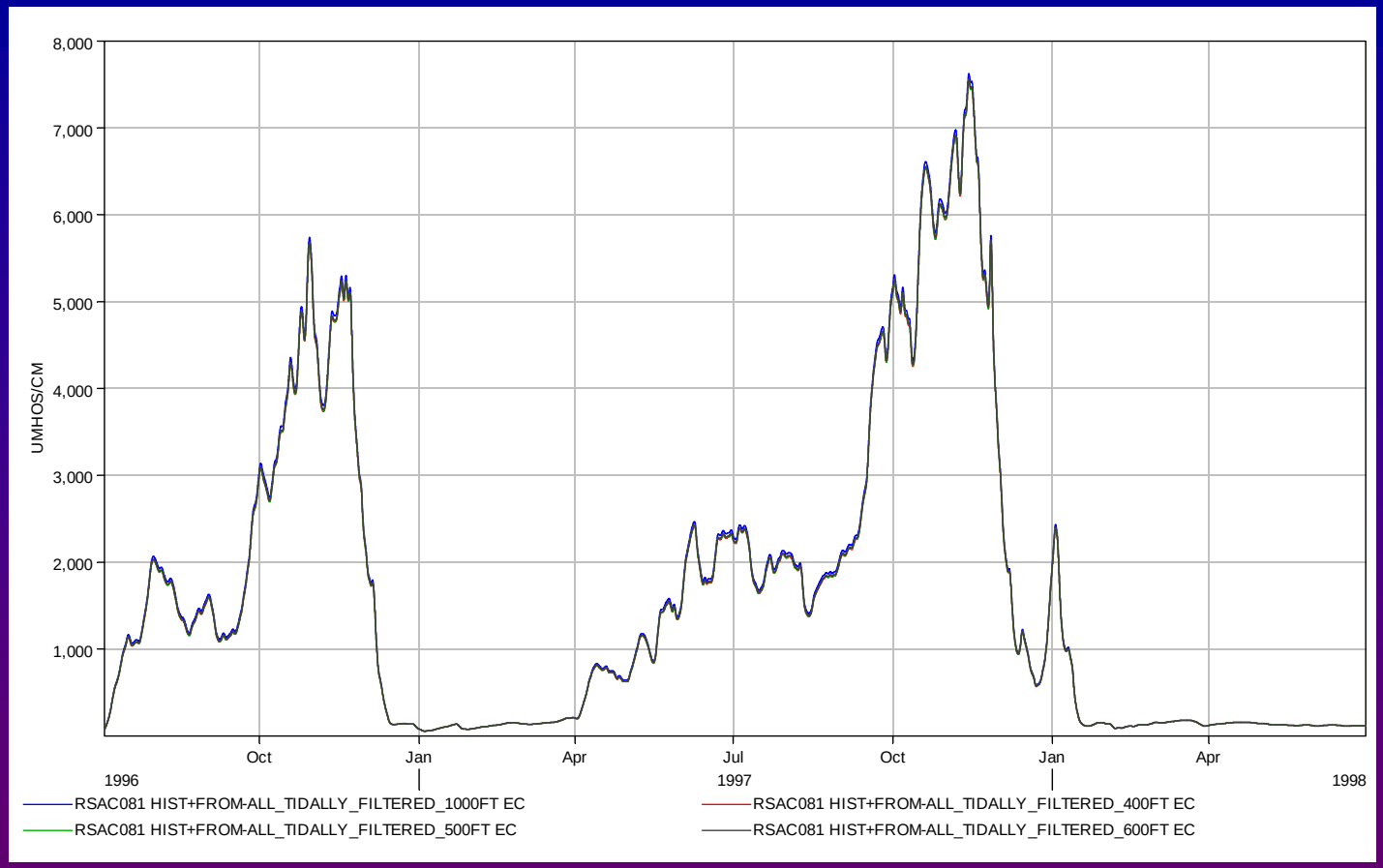
EC at Bacon Island Old River with time steps 15, 5, 3, 1 minutes

New Model Results



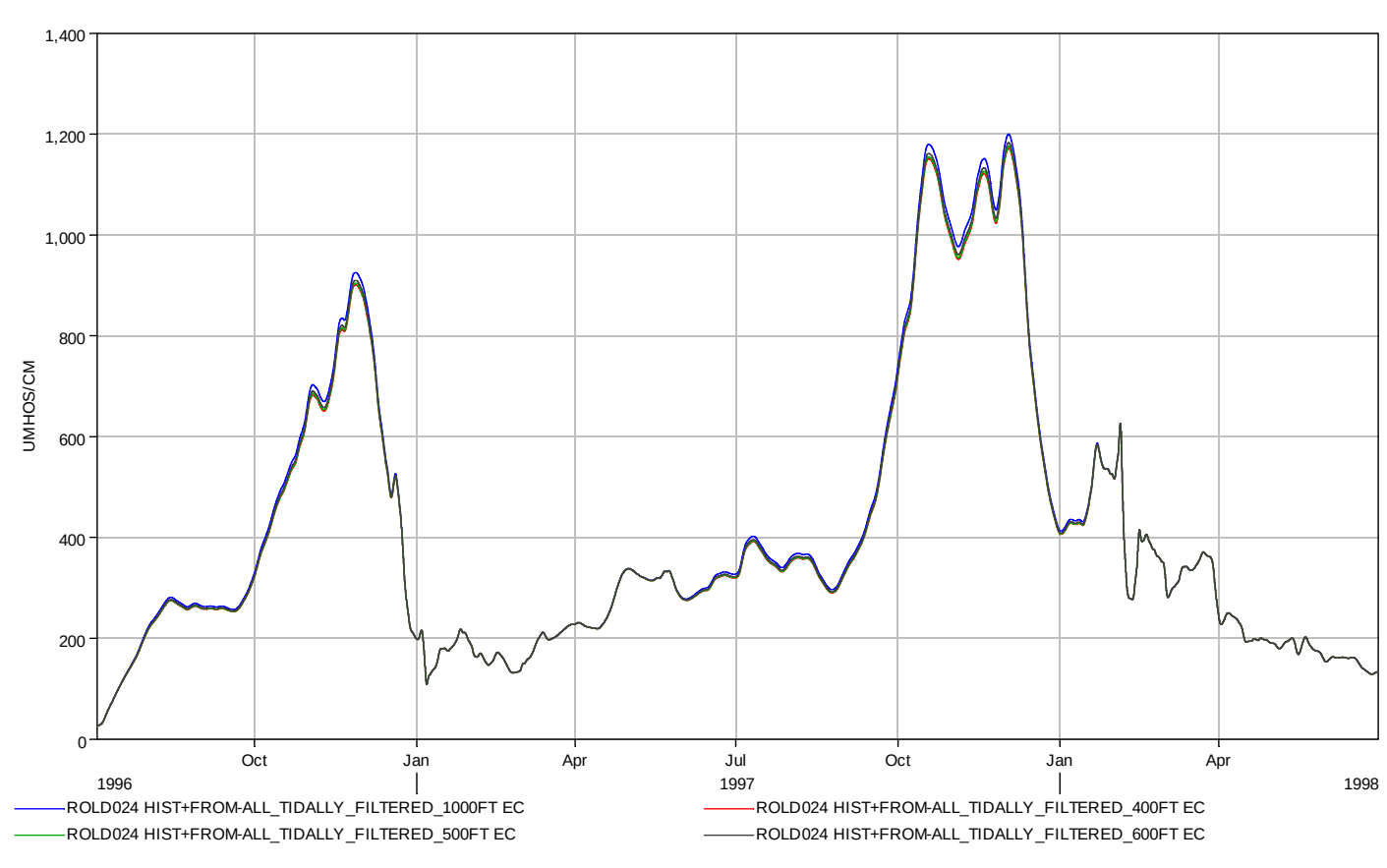
EC at Clifton Court Forebay with time steps 15, 5, 3, 1 minutes

Parcel size sensitivity test



EC at Collinsville with parcel size 1000, 600, 500, 400 ft

Parcel size sensitivity test



EC at Bacon Island with parcel sizes 1000, 600, 500, 400 ft

Conclusions

- The new model shows good qualitative convergence with time step and parcel size.
- Recommended time step is 5 minute, and parcel size 500 ft.
- The new model is likely to give more reliable results.
- The new model need to be calibrated before we can compare old and new model results.

Questions?